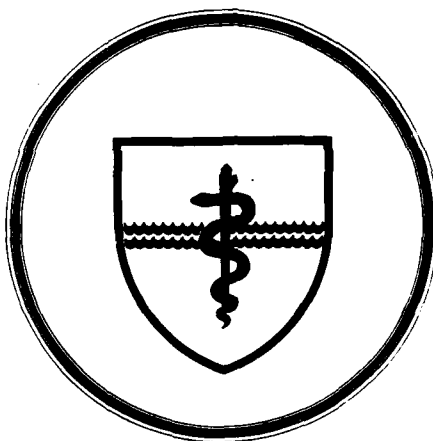


NAVAL SUBMARINE MEDICAL RESEARCH LABORATORY

SUBMARINE BASE, GROTON, CONN.

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REPORT NUMBER 1124

VOLATILE ORGANIC COMPONENTS OF AIR SAMPLES COLLECTED
FROM VERTICAL LAUNCH MISSILE CAPSULES

by

D. V. Tappan
D. R. Knight
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Commanding Officer
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27 September 1988

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FROM VERTICAL LAUNCH MISSILE CAPSULES

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APPROVED AND RELEASED BY

C. A. Harvey

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SUMMARY PAGE

THE PROBLEM

Missile operators aboard 688 class submarines have occasionally reported a distinctive, strong odor during pre-launch pressurization-ventilation maintenance of the Vertical Launch System (VLS) missile capsules. Air samples were collected for analysis of volatile organic components in an attempt to characterize the odor for evaluation of its possible toxicity.

FINDINGS

Gas chromatographic/mass spectroscopic analyses detected numerous organic components in the air from the missile capsules but the compounds identified are among those that are commonly found in submarine air. Although some of the organic compounds measured are potentially harmful at sufficient concentrations, no individual material was found to be present at toxic levels. It should be noted that the strong odor was not detected at the time that these samples were collected.

APPLICATIONS

It was demonstrated that pressure-ventilation of VLS missile capsules adds significantly to the already heavy concentration of volatile organic components in submarine air. The variability between air samples from the various missile capsules indicates that further sampling and analysis should be performed to better evaluate the possibility of adding significant toxicants to submarine air from the maintenance of the missile capsules.

ADMINISTRATIVE INFORMATION

This investigation was conducted per request from Naval Sea Systems Command. The manuscript was submitted for review on 4 Aug. 1988, approved for publication on 27 September, 1988, and designated NSMRL Laboratory Report No. 1124.

ABSTRACT

Gas chromatographic/mass spectroscopic analyses are presented for the volatile organic components found in air samples collected from the inboard vents from Vertical Launch System (VLS) missile capsules aboard a 688 class submarine. Similar analyses were also conducted for a sample of the ship's high pressure air used to fill the missile tubes.

A wide variety of organics was detected in the air from the missile capsules; and while no unique components have yet been identified, a significant contribution has been shown to be made by pressure-ventilation of the VLS capsules into the submarine atmosphere which is already heavily laden with volatile organic compounds.

The most apparent conclusion from these preliminary analyses is that the mixtures of organic components in the air within VLS missile capsules vary greatly from capsule to capsule (and probably from time to time). Many such samples need to be investigated to provide sufficient information to judge the seriousness of the possibility of venting toxic components into the submarine atmosphere during the maintenance or firing of VLS missiles. (AW)

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INTRODUCTION

The newer SSN 688 class submarines are equipped with the Vertical Launch System (VLS) for "cruise" ("tomahawk") missiles. Several ships carry missiles for the purpose of evaluating the operation and maintenance of the VLS during deployment. The basic features of the system are shown in Figure 1. Each missile is housed in a protective metal capsule that contains an opening at the top. The opening of the capsule is sealed by a rubber-metal composite diaphragm. An air space is trapped above and below the diaphragm at equal pressures of approximately 14.7 psia when the capsule is loaded into one of the missile tubes and the missile hatch is closed. Sea-water pressure is used to keep the missile hatch closed during submergence with no additional locking mechanism on the hatch. The pressure differential across the diaphragm, as well as the capsule moisture and temperature, are continuously monitored.

Maintenance procedures require frequent pressurization-ventilation of the capsule. The pressure-vent system automatically maintains a pressure difference across the diaphragm of 3.8-7.2 psid above seawater pressure. This is accomplished by transferring compressed gas from the 700 psig submarine air system into the capsule. If capsule air pressure becomes too high, it is vented back into the submarine's forward compartment.

Missile operators have reported a distinctive and unknown odor during pre-launch pressurization and venting of 688 submarine VLS missile tubes. These reports prompted a request by the Naval Sea Systems Command (NAVSEA) for the Naval Submarine Research Laboratory (NSMRL) to investigate the potential hazard of the offensive gas (1). NSMRL's response was to question witnesses, observe the pressurization-ventilation procedure aboard ship, and analyze air samples taken from the vented missile tubes. This report contains the investigative findings to date.

According to two witnesses, a submarine weapons officer and a civilian engineer, a strong odor was released from the ventilation valve during pressurization-ventilation of the VLS missiles aboard the moored USS PITTSBURGH (SSN 720) during late 1986. The odor lingered in the forward space of the ship for about 30 minutes before one of the witnesses chose to leave the area to breathe fresh air. He developed a slight headache, but no other signs or symptoms of illness as a result of exposure to the odorous pollutant(s). Other on-site personnel did not become sick despite the fact that they were breathing the air without wearing respirators. Since the odor was thought to be similar to that of "paint" or "epoxy paint", the missile tube was subsequently stripped of its protective coating. An odor was again detected aboard the USS PITTSBURGH in January, 1987, during the same pressurization-ventilation procedure. The odor was strong, but not "camphorated". No adverse health effects were observed.

In August, 1987, the authors of this report collected air samples from the pressure-ventilation valve, APV-()-14 (see Figure 1), of missile tubes #11 and #15 aboard the USS PROVIDENCE (SSN 719). The missile capsules did not contain warheads or gas generators. Missile capsule #15 was vented inboard while 3

observers attempted to identify any odor in the incoming gas/air. A mild inoffensive odor was described as being similar to dried paint. A stainless steel sampling bomb was connected to valve #14 and one liter of air was collected. Then, pressure ventilation of capsule #15 was performed while the observers sniffed the vented air. The same or a similar odor was detected. One liter of air was collected from missile capsule #11 without attempts to detect or identify an odor. Vented air from missile capsule #13 was sniffed by a fourth observer, familiar with the characteristic odor of T-H Dimer, (Tetrahydromethylcyclopentadiene), RJ4 RAMJET fuel. He was unable to detect the odor of this fuel. A one liter sample from the 700 psig high pressure air supply, which is routinely used to pressurize the missile tubes, was collected for comparison against the missile tube samples. An odor indistinguishable from those of the the missile tubes was also noted in the gas from the 700 psig air line.

METHODS

Analytical Procedures. Gas chromatograph/mass spectrometer (GC/MS) analyses were performed on a Hewlett-Packard (HP) 59970 MS Chem Station using a Model 5970 Mass Selective Detector and a HP-5880 Gas Chromatograph. Air samples were collected from the VLS capsules aboard the USS PROVIDENCE in cleaned, evacuated, 1-liter stainless steel cylinders attached by secure fittings to the gas sources described above. Volatile organic contaminants of the air samples in the cylinders were collected by drawing the air through glass columns containing glass beads, Tenax-GC, Amborsorb XE-340, and charcoal (Cat. # 7142, Envirochem, Inc., Kemblesville, PA) at a pumping rate of 0.3 liter per minute. The data of this report represent 1 to 5 liter air samples transferred from the cylinders into teflon collecting bags (Cat. #41261, Alltech Corp.) so that flow rates and volumes could be measured at one atmosphere pressure. In those cases in which the collected samples in the steel cylinders were at or near ambient pressure, analytical grade helium was flushed through the cylinders into the teflon bags at about 0.1 liter per minute to allow thorough mixing and washout of the contents of the cylinder.

Secure connections between the steel collection cylinders and teflon bags were made with Swagelock fittings and copper or teflon tubing. The cylinders, bags, and connections as well as the helium used for purging the air samples had been previously checked for cleanliness by GC/MS analyses. The steel collecting cylinders were cleaned by evacuation and flushing with Freon 113, followed by repeated evacuation, heating and refilling with helium, until satisfactory GC/MS analyses were obtained on helium samples equilibrated overnight in the bottles. The mixed resin absorption tubes were sealed in glass containers with teflon lined caps before and after sample collection. The tubes were stored at -7°C until the samples were analyzed. A heat-gun was used to warm the steel collection/storage cylinders to about 50°C to assist in the removal, under vacuum, of any precipitated or adsorbed organic components on the cylinder walls.

Components adsorbed on the collection tubes were eluted by heating the tubes in an Envirochem Unacon Series 310 desorbing and concentrating apparatus which injects the concentrated samples directly onto the gas chromatographic

column for separation. The chromatograms for this work were obtained using RTX-5 capillary columns, 0.32 mm ID x 50 meters with 1 micron adsorbent coating (Cat. # 10254; Restek Corp., Port Matila, PA). The column temperature was held at 30°C for 8 minutes after sample injection and then was increased by 3°C per minute until 150°C was attained. Although most of the organic materials were eluted from the column at less than 150°C, the temperature of the chromatographic oven was subsequently increased at 8°C per minute to 270°C where it was held for 30 minutes to thoroughly clean the column for future analyses. The times shown on the chromatograms presented here include a period of approximately 12 minutes during which the samples are being eluted from the collection columns by the Unacon apparatus. Library searches of MSD spectra were performed using the Hewlett-Packard NBS REVF spectral library. Data handling routines consisted primarily of locally developed software.

The sample of T-H Dimer analyzed was hand delivered to our laboratory by a representative of FMS 393 EB-NAVSEA in a polyethylene bottle from which it was transferred to a glass container with teflon lined cap and refrigerated until analyzed.

Identification of air contaminants. The most expedient approach to the identification of mass spectrographic results with computer assistance involves a search of a library of mass spectral data for the best match(es) to the spectra of the peaks of an MSD total ion chromatogram. However, such an approach only identifies statistically probable matches for the unknown spectra. In practice, the calculated reliabilities for as many as 20 possible matches with a spectrum to be identified are often nearly identical. The reliability of match quality is often also very dependent upon differences in response between the instrument being used for analysis and the instruments used to compile the library data. To overcome such difficulties in identifying individual chromatographic peaks, a library search must be supplemented by other information about the components of an analyte separated and analyzed under a particular protocol.

Chromatographic retention times may be used to provide such confirmatory information for better identification of organic materials in samples of the kind analyzed here. To acquire chromatographic data applicable to our analytical methods, we are in the process of establishing a reference library of compounds known or likely to found in submarine atmospheres. However, the acquisition of such a library is both expensive and time consuming since the mixture of compounds found in submarine air is extremely complex. In developing an initial list of organic materials to be used as reference standards for these studies, we considered the levels of components found in preliminary analyses of submarine air by O'Neill, et al (3) and by Su (4), the solvents used during construction and maintenance of submarines (5), and organic components that have been detected aboard British (6) and U.S. (7,8) submarines. Table 1 lists organic compounds that were available as reference markers at the time of investigations reported here. All of these materials have been reported in submarine environments.

TABLE 1

PRELIMINARY LIST OF ORGANIC COMPOUNDS USED AS REFERENCES FOR ANALYSES
OF SUBMARINE AIR

DICHLOROMETHANE	BENZENE	2-ETHOXYETHANOL ACETATE
HEXANE	HEPTANE	2-BUTOXYETHANOL
CHLOROFORM	2-ETHOXYETHANOL	1,3,5-TRIMETHYLBENZENE
2-BUTANONE	4-METHYL-2-PENTANONE	1,2,4-TRIMETHYLBENZENE
1,1,1-TRICHLOROETHANE	TOLUENE	INDENE
1,2-DICHLOROETHANE	o-XYLENE	NAPHTHALENE
CARBON TETRACHLORIDE	p-XYLENE	FREON 11; FREON 12
T-H DIMER		

Data have been collected for the gas chromatographic retention time and the mass spectrum under our experimental conditions for each compound listed above. This information was used both in algorithms for locating specific compounds in limited areas of GC/MS chromatograms and for verifying the findings of library searches of the ion chromatographic data obtained for the air samples.

Since we can not identify all of the unknown organic compounds in the air samples collected in this work by direct comparisons with the reference compounds that are currently available to us, a library searching routine which corrects the spectra of the chromatographic peaks for most of the interfering background noise was employed to provide tentative identification for the separated materials. The data provided with Figures 1-3 indicate that we have been able to classify a majority of the chromatographic peaks at least into broad classes by these methods of analysis. In many cases, visual inspection of the spectra was required to substantiate or develop the classifications.

RESULTS

Figures 2 to 4 show the Total Ion Chromatograms for the air samples collected from the VLS capsules and from the submarine's high pressure air supply at the time of offloading of the missiles described previously. The chromatograms of Figures 2 and 3 were obtained from the analyses of the air samples collected from VLS capsules, #11 and #15, while Figure 4 presents similar information for the air sample collected from the PROVIDENCE's high pressure (700 PSIG) air supply. The data in Figure 4A were obtained from an air sample of approximately the size of the samples represented by Figures 2 and 3. It was necessary to analyze a larger sample of the ship's high pressure air, as shown by Figure 4B, in order to obtain results that could be better compared with those of the samples from the VLS capsules. With the exception of the poorly resolved initial peak(s), which contain primarily Freon(s), the concentration of organics is higher in the air samples from the VLS capsules than in the air supply used to charge the capsules.

A comparison of the data presented in Figures 2A and 2B demonstrates, both qualitatively and quantitatively, the efficiency of the methods used for recovery of the samples from the collection bottles. The contents of the bottle, depicted in Fig. 2A, were removed without the aid of heat on the collection container and may be seen to have been about 99% recovered with the original cool helium flush (cf Fig. 2B). No unique peaks were detected in the chromatogram shown in Fig. 2B, obtained from a 5 liter second flush of the bottle with helium accompanied by the application of heat.

After the results shown in Figures 2A and 2B had been obtained, the organic components shown in Figure 3 were removed from the collection bottle with the aid of heat on the vessel's walls to make the sample recovery a one-step process. Although the pattern of components found in the sample of air from missile tube #15 shown in Figure 3 is very different from that of Figure 2A, the differences can not be attributed to the differences in the methods used in recovering the samples from the collection bottles. Different peaks from those of Figure 3 were obtained from the air sample obtained from missile tube 11 (Figs. 2A and 2B) with or without the application of heat to the walls of the collection bottle. Only about half of the compounds identified in the samples of air obtained from the two VLS capsules are similar.

Figures 5A to 5C present preliminary information about the chromatographic characteristics of RJ4 fuel, T-H Dimer, when added to and eluted from the same type of sample collection tubes that were used to trap organic components from air samples. The two chromatographic markers shown in Figures 5B and 5C were heptane and indene. Figures 5A and 5B represent samples containing T-H Dimer with and without the marker compounds while Figure 5C shows a chromatogram of the markers alone. These figures indicate that the RJ4 fuel separates into several fractions which elute between 52 and 60 minutes in this analysis. The consistency of the pattern of the peaks indicates that, under our conditions, this fuel material consists of several molecular species with similar chemical properties.

We have not attempted to characterize the components of the various peaks of T-H Dimer beyond the fact that their mass spectra indicate the predominance of hydrocarbon compounds. The three major peaks chromatographing: at 53.9 minutes, at 56.8 and 57.0 minutes (the doublet), and at 59 minutes, all show ions of m/z 166 in their mass spectra. This finding presents initial evidence that some of these peaks may, in fact, represent isomers of Tetrahydromethylcyclopentadiene. We have been unable to detect evidence, from the mass spectral data, of the presence of T-H Dimer in the VLS air samples collected aboard the USS PROVIDENCE, despite the presence of a few small chromatographic peaks in the 52-60 minute region of Figure 2A.

DISCUSSION

Three aspects of these studies need to be considered to properly evaluate their importance to the submarine force. First, the difficulties that were encountered in obtaining samples that accurately represent the air content of the VLS capsules must be understood. Secondly, we must appraise the

significance of the the volatile organic components released into the submarine environment from the pressure-ventilation of the missile capsules. These air contaminants might ultimately be more important to the health of submariners than the specific noxious odor which was apparently not present in the air samples collected and which has not yet been identified. Finally, an estimate must be made of any additional work that will be needed to answer the question of the seriousness of the problems introduced by the venting of the VLS missile capsules into the submarine atmosphere.

With the allowable differences in capsule pressures and the variability in plumbing lines from one capsule to another, it is to be expected that the air samples in this preliminary work would not be of identical size or necessarily of identical origin from within the missile tubes studied. When the air samples were collected, an initial burst of air was allowed to escape from each missile capsule to help assure that samples analyzed would not represent stagnant air trapped in the piping and fittings. An evacuated cylinder was then attached with quick-disconnect fittings to the exhaust port of the capsule being sampled. Thus, the gas entering the sampling cylinders represented air from the pressure-vent system and the VLS capsule, but the actual history of the samples within each capsule was somewhat uncertain. While adherence of sample material to the walls of the collection vessels seems to account for only a very small part of the differences observed between the samples studied, several other possibilities exist for the introduction of experimental errors. Different rates of off-gassing, lengths of exposure to materials within the capsules, errors in sampling due to such problems as trapped air pockets in the pressure-vent lines, or numerous other technical complexities may be involved in producing the observed variability between samples. T-H dimer has been shown to readily plate onto steel surfaces (9), a factor which seems not to have significantly influenced our results as described here.

Despite differences in the analyzed air samples that may have arisen from technical problems associated with the collection process, it is apparent from the mixture of organic components found in the air from the capsules that chemical conditions may differ greatly from one tube to another. A comparison of Figure 4 with Figures 2 and 3 also indicates that many of the contaminants of the air in the missile tubes probably arise from contact with the missiles or conditions within the capsules rather than being introduced into the capsules from the ship's high pressure air system. However, variability in the ship's service air, used to pressurize the capsules from time to time, could account for some of the difference between the component mixtures found in the two VLS air samples analyzed.

The individual peaks of the GC/MS chromatograms have been identified as a variety of organic components which are quite widely found in the atmosphere of submarines either at dockside or when operating at sea. None of these solvents, hydrocarbons, or other organics appear at this time to be present in concentrations that would currently be considered to be dangerously high, particularly since they are diluted by at least a factor of 100 as they are vented into the submarine atmosphere from the missile capsules. The organic components found (Figures 2-4) have been estimated to be present in

concentrations of less than 500 ppb (parts per billion) in the air samples analyzed. Of the organic materials detected, benzene is by far the most toxic. The allowable 90-day exposure limit for this compound in submarine atmospheres is currently set at 1 ppm (7). This limit as well as the limits for the other compounds identified seem to be safely met by the dilution of the VLS air into the submarine atmosphere.

Obviously much more work needs to be done toward identification of organic constituents that can be introduced into the submarine atmospheres from the pressure ventilation of the VLS missile capsules. The serious odor which was reported to occur as a result of this operation was not necessarily located or identified. The analytical work to date has demonstrated the presence of a variety of solvents and hydrocarbons which may account for the "paint" smell of the gas samples as they were collected. The present evidence is insufficient to indicate whether T-H Dimer, RJ4 fuel, might figure significantly in producing the reported odor since the air samples analyzed probably did not contain the offending odor(s).

A important point that should be made in considering data obtained from the analysis of complex mixtures of organic compounds such as those studied here is that the potential biological effects of these mixtures may arise either from the individual compounds involved or from the combined influence of the mixture of compounds. Although most of the effort of analyzing these samples must be spent in identifying individual components, the biological effects of mixtures of organics in the environment need more emphasis now than do the effects of individual material(s). No individual compounds have yet been shown to be present in dangerous concentrations or to be responsible for a strong noxious odor. Nevertheless most of the organics detected present significant health hazards when they occur in sufficient concentrations. Since very little evidence exists concerning the toxic effects of mixtures of organic compounds, serious attention needs to be given in this laboratory and elsewhere to the toxic effects of mixtures of volatile organic compounds such as those arising from the equipment and activities of the submarine environment.

SUMMARY

Gas chromatographic/mass spectroscopic analyses are presented for the volatile organic components found in air samples collected from the inboard vents from Vertical Launch System (VLS) missile capsules aboard a 688 class submarine. Similar analyses were also conducted for a sample of the ship's high pressure air used to fill the missile tubes.

A wide variety of organics was detected in the air from the missile capsules; and while no unique components have yet been identified, a significant contribution has been shown to be made by pressure-ventilation of the VLS capsules into the submarine atmosphere which is already heavily laden with volatile organic compounds.

The most apparent conclusion from these preliminary analyses is that the mixtures of organic components in the air within VLS missile capsules vary

greatly from capsule to capsule (and probably from time to time). Many such samples need to be investigated to provide sufficient information to judge the seriousness of the possibility of venting toxic components into the submarine atmosphere during the maintenance or firing of VLS missiles.

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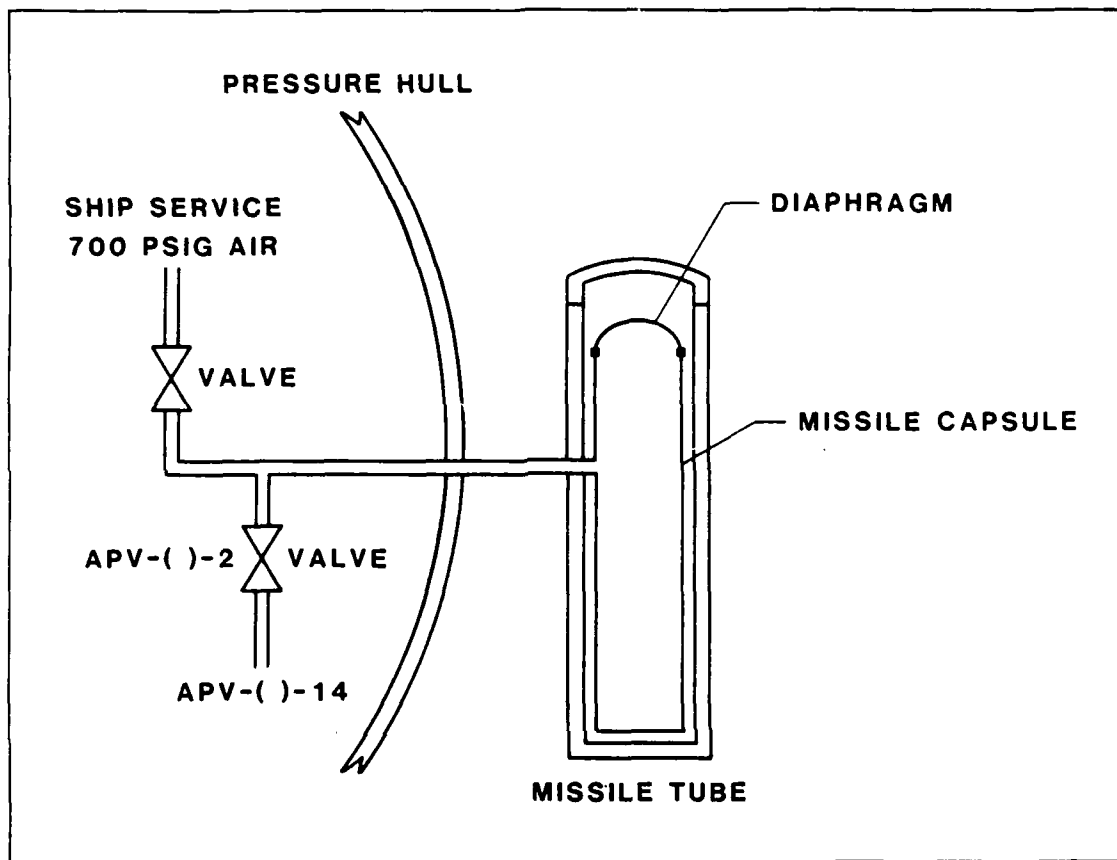
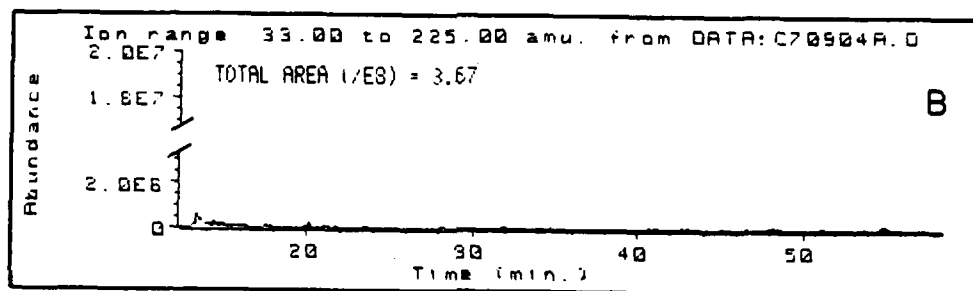
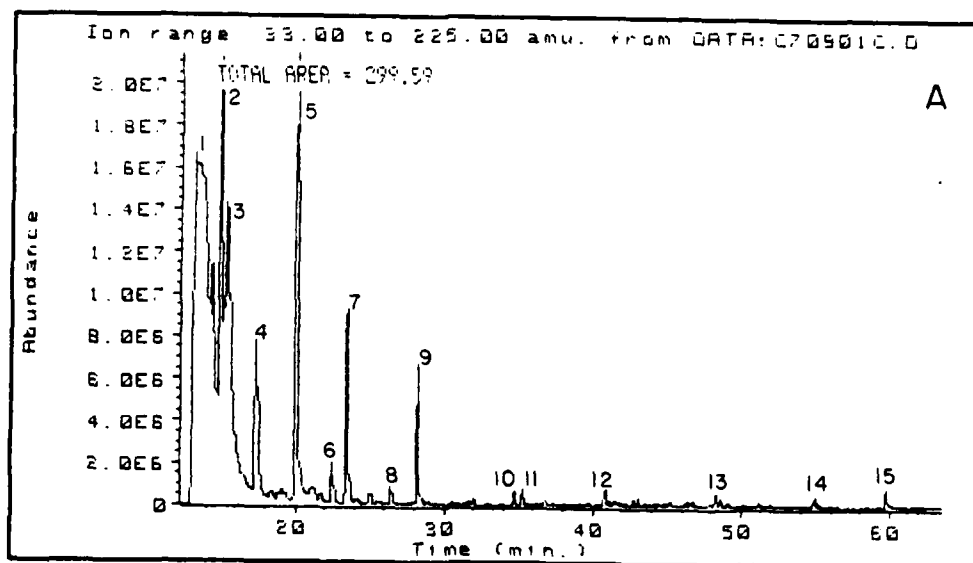


FIGURE 1. Simplified schematic of 688 class submarine pressure-ventilation system of VLS missile capsules to indicate source of air samples collected. Not to scale.



Partial identification of GC/MS peaks (Figure 2A):

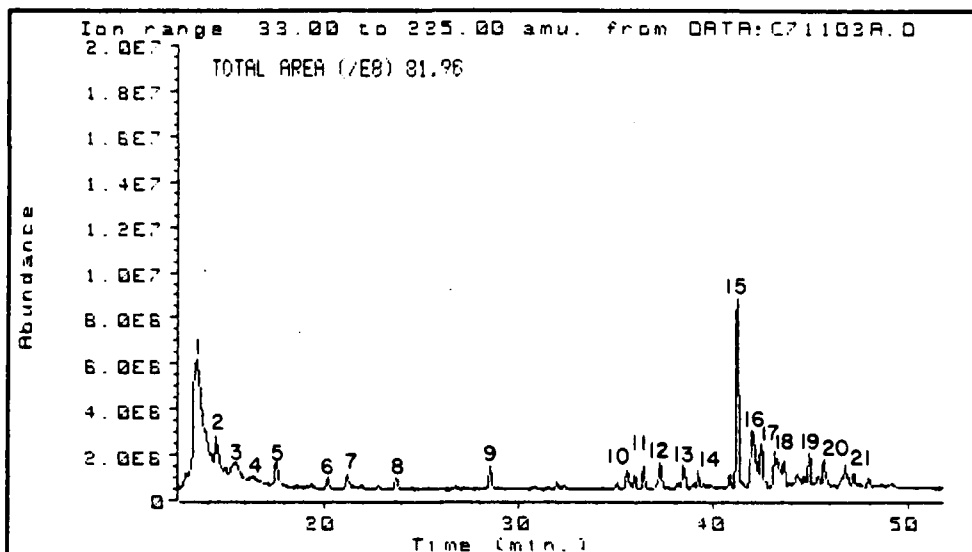
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|-----------------------------|---|
| 1. Freons | 9. Toluene |
| 2. 1,2-Dichloroethene | 10. Ethylbenzene (33)* |
| 3. Dichloromethane | 11. Xylene(s) |
| 4. 2-Butanone | 12. Aliphatic hydrocarbon [C10H22 (52)] |
| 5. 1,1,1-Trichloroethane | 13. Mixture partly aromatic hydrocarbon (20-60) |
| 6. Aliphatic Hydrocarbon* | 14. Unreliable matches (11)* |
| 7. Chlorinated hydrocarbon* | 15. Unreliable matches (15)* |
| 8. 2-Methylpentanal (70)* | |

* Library matches only; reference standards are not yet available. Numbers in parentheses show values calculated by search algorithm for match reliabilities (scale = 0-100). Matches <50 should be regarded with suspicion while values >90 indicate essentially perfect matches.

Results obtained by author evaluation of spectra. Library searches did not yield satisfactory identifications.

Reference standards were available for verifying chromatographic retention times and spectral identities for compounds not marked or for which match reliability estimates are not given.

FIGURE 2. (2A) Contents of 1 liter cylinder collected under vacuum in vent stream from missile capsule #11, USS PROVIDENCE. Cylinder contents were flushed onto sorbent tube with 3.7 liters of helium. (2B) Four liter He flush, with heating, of collection cylinder after removal of sample shown in Figure 2A.

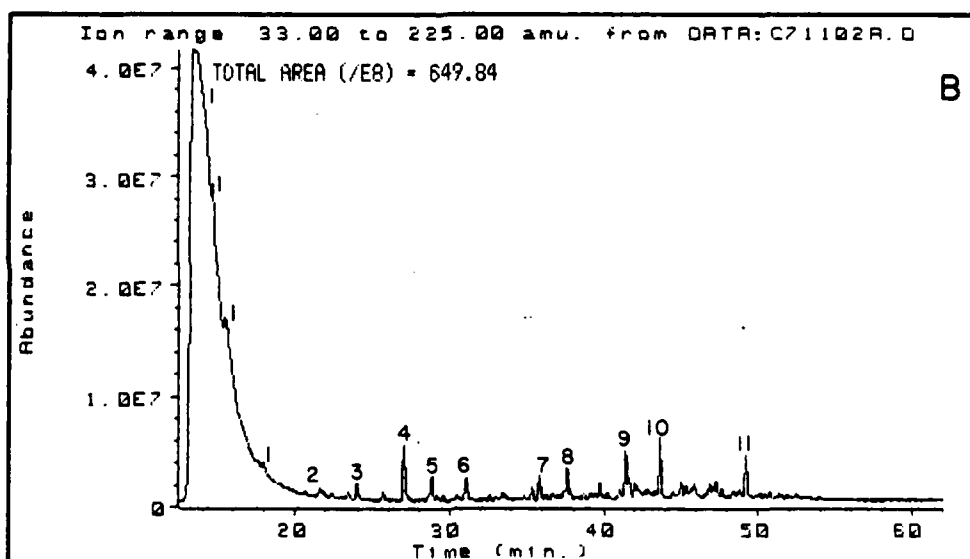
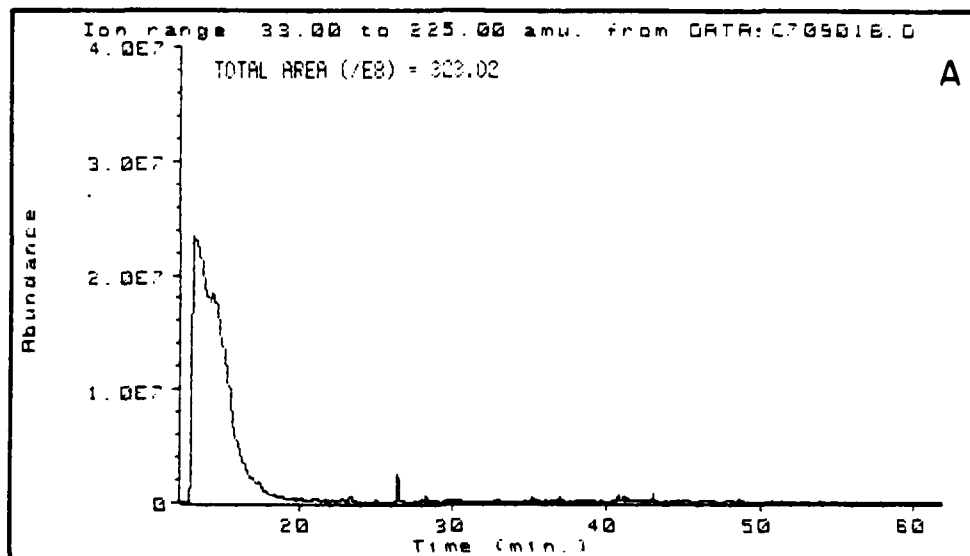


Partial identification of GC/MS peaks:

- | | |
|--|---|
| 1. Freons & alkene (23)* | 8. Trichloroethene (99)* |
| 2. 2-Propanone (58)* | 9. Toluene |
| 3. Dichloromethane | 10. Xylene(s) |
| 4. Chlorinated hydrocarbon [1-Chloro-1-propene (31)] | 11-21. Aliphatic hydrocarbons * |
| 5. 2-Butanone | 15. Branched aliphatic hydrocarbon [C ₁₁ H ₂₄ (76)] |
| 6. 1,1,1-Trichloroethane | |
| 7. Benzene | |

* See Figure 2 for explanation of symbols.

FIGURE 1. Contents of 1 liter cylinder collected under vacuum in vent stream from missile capsule #15, USS PROVIDENCE. Cylinder contents were flushed, with heating, onto sorbent tube with 5 liters of helium.



Partial identification of GC/MS peaks (Figure 4B):

- | | |
|---------------------------------------|--|
| 1. Freons | 7. Xylene(s) |
| 2. Benzene | 8. Aliphatic hydrocarbon [C9H20 (83)] |
| 3. Pentanal (43)* | 9. Trimethylbenzene(s) |
| 4. 4-Methyl-2-pentanone | 10. Aliphatic hydrocarbon [C10H22 (84)]* |
| 5. Toluene | 11. Aliphatic hydrocarbon [C11H24 (96)] |
| 6. Aliphatic hydrocarbon [C8H20 (40)] | |

* See Figure 2 for explanation of symbols.

FIGURE 4. Analysis of 1.3 liter (4A) and 5 liter (4B) air samples (measured at 1 PSIC) from collection cylinder filled from high pressure air supply, USS PROVIDENCE.

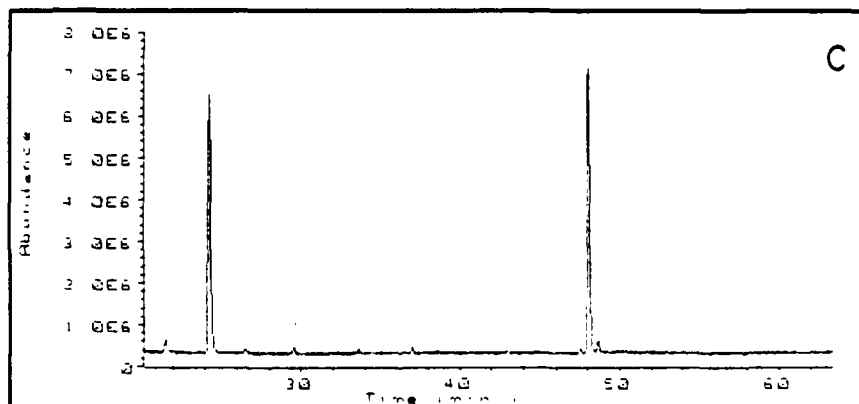
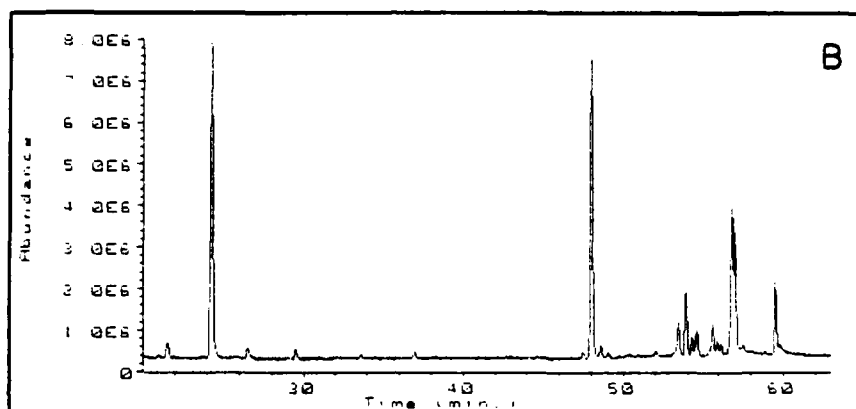
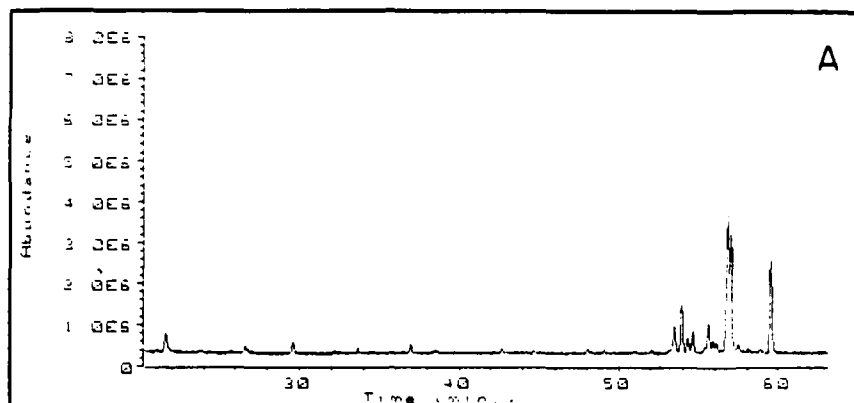


FIGURE 5. (5A) GC/MS total ion chromatogram (TIC) of T-H Dimer, RJ4 fuel, eluted from glass bead-Tenax-Ambersorb-charcoal sorbent tube. (5B) TIC of T-H Dimer in presence of heptane and indene chromatographic reference markers. (5C) TIC of chromatographic reference markers alone.

APPENDIX A

Enclosure (1) to:
87-DAZ-560

OUTGASSING CANDIDATES: CLS NON-METALLIC MATERIALS

CLS COMPONENT / ITEM	MATERIAL
Cable Assembly (typical)	Neoprene, MIL-R-6855, Cl II GR 60
Locking Compound	MIL-S-22473
Antiseize Compound	Led Plate 250, MIL-A-907
Grease	MIL-G-27617
O-Rings (typical)	MS 28775
Hose Assembly (JCM-14169)	Teflon, MIL-P-22296
	Dacron, V-T-285
	Nylon, ASTM-D-789
	Viton, Kevlar
	Preece, Inc.
	Code Ident. No.: 21392
	Part No.: 6553-1
Closure Assembly (JCM-14048)	Nitrile rubber
	MIL-R-6855 Cl I GR 50
	Coated Nylon Fabric
	MIL-C-20696
	Silicone Lubricant (JCM-14292)
	Dow Corning (Slipicone)
	FSCM No.: 71984
	Part No.: 316
Peel Strip	Teflon
	AMS 3652

OUTGASSING CANDIDATES: CLS NON-METALLIC MATERIALS

Continued

CLS COMPONENT / ITEM	MATERIAL
Vertical Support Assembly and the CLS (JCM-14031)	Polyurethane paint system JCM-1913, JCM-14352, JCM-14353, JCM-1907 (process specifications) Nitrile rubber Barry Controls FSCM No.: 13636 Part No.: 94323-1
Lateral Support Pads and Launch Seals (JCM-14309, JCM-14311, JCM-14165 JCM-14102, 14140)	Clear acrylic lacquer TT-L-26 TY I Ink TT-I-1795 TY I Urethane Curing Agent Ihara Chemical FSCM No.: None Part No.: MBOCA Activator-M or Palmer Davis Seika FSCM No.: None Part No.: BIS-AMINE A. Pads: Liquid Polyurethane Uniroyal FSCM No.: 80196 Part No.: Adiprene L-100 Seals: Liquid Polyurethane Uniroyal FSCM No.: 80196 Part No.: Adiprene L-167

OUTGASSING CANDIDATES: CLS NON-METALLIC MATERIALS

Continued

CLS COMPONENT / ITEM	MATERIAL
Epoxy (JCM-14308, JCM-14309, JCM-14312, JCM-14317, JCM-14318)	Lord Corp. FSCM No.: 30676 Part No.: Fusor 304-1, Fusor 304-2
	High Tack Urethane Adhesive Lord Corp. FSCM No.: 30676 Part No.: Tycel 7002, Tycel 7202
	Epoxy Paint Coating System MIL-P-23236 Sovapon System #3 Valspar Corp. FSCM No.: 77988
	Unfilled Resin Adhesive Epoxy H. B. Fuller Co. FSCM No.: 92528 Part No.: Resiweld 7004
	Fumed Silica Filler MIL-S-14760 Cabot Corp. FSCM No.: 80798 Part No.: CAB-O-SIL (M-5)

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SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE				Form Approved OMB No 0704-0188	
1a REPORT SECURITY CLASSIFICATION			1b RESTRICTIVE MARKINGS		
2a SECURITY CLASSIFICATION AUTHORITY			3 DISTRIBUTION / AVAILABILITY OF REPORT		
2b DECLASSIFICATION / DOWNGRADING SCHEDULE			Approved for public release; distribution unlimited		
4 PERFORMING ORGANIZATION REPORT NUMBER(S) NSMRL Report 1124			5. MONITORING ORGANIZATION REPORT NUMBER(S)		
6a. NAME OF PERFORMING ORGANIZATION Naval Submarine Medical Laboratory		6b OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION Naval Medical Research and Development Command		
6c. ADDRESS (City, State, and ZIP Code) Box 900, Naval Submarine Base New London Groton, CT 06349-5900			7b. ADDRESS (City, State, and ZIP Code) Naval Medical Command, National Capital Region, Bethesda, MD 20814-5044		
8a. NAME OF FUNDING / SPONSORING ORGANIZATION		8b. OFFICE SYMBOL (If applicable)	9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER		
8c. ADDRESS (City, State, and ZIP Code)			10 SOURCE OF FUNDING NUMBERS		
PROGRAM ELEMENT NO		PROJECT NO	TASK NO	WORK UNIT ACCESSION NO	
61					
11. TITLE (Include Security Classification) Volatile Organic Components of Air Samples Collected from Vertical Launch Missile Capsules					
12. PERSONAL AUTHOR(S) Iappan, D.V., Knight, D.R., Heyder, E. and Weathersby, P.K.					
13a. TYPE OF REPORT Summary		13b. TIME COVERED FROM _____ TO _____		14. DATE OF REPORT (Year, Month, Day) 27 Sep 88	15. PAGE COUNT 19
16. SUPPLEMENTARY NOTATION					
17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)		
FIELD	GROUP	SUB-GROUP	Submarine Medicine; Submarine Atmospheres; Volatile Organic Pollutants; Environmental Toxicology		
19. ABSTRACT (Continue on reverse if necessary and identify by block number)					
<p>Gas chromatographic/mass spectroscopic analyses are presented for the volatile organic components found in air samples collected from the inboard vents from Vertical Launch System (VLS) missile capsules aboard a 688 class submarine. Similar analyses were also conducted for a sample of the ship's high pressure air used to fill the missile tubes.</p> <p>A wide variety of organics was detected in the air from the missile capsules; and while no unique components have yet been identified, a</p>					
20. DISTRIBUTION / AVAILABILITY OF ABSTRACT <input checked="" type="checkbox"/> UNCLASSIFIED/UNLIMITED <input type="checkbox"/> SAME AS RPT <input type="checkbox"/> DTIC USERS			21. ABSTRACT SECURITY CLASSIFICATION Unclassified		
22a. NAME OF RESPONSIBLE INDIVIDUAL			22b. TELEPHONE (Include Area Code)		22c. OFFICE SYMBOL

DD Form 1473, JUN 86

Previous editions are obsolete

S/N 0102-LF-014-6603

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significant contribution has been shown to be made by pressure-ventilation of the VLS capsules into the submarine atmosphere which is already heavily laden with volatile organic compounds.

The most apparent conclusion from these preliminary analyses is that the mixtures of organic components in the air within VLS missile capsules vary greatly from capsule to capsule (and probably from time to time). Many such samples need to be investigated to provide sufficient information to judge the seriousness of the possibility of venting toxic components into the submarine atmosphere during the maintenance or firing of VLS missiles.